Derivatives & Risk Management

- Interest-rate derivatives
  - FRA’s & T-Bill futures
  - Swaps
    - Hedging International Financing Transactions
    - All-In Cost of Capital Computations
- T-Bond & T-Note futures
  - This lecture

Part III:
Interest Rate Derivatives
Interest-Rate Derivatives *(Recap. slide)*

- Forward rate agreements (FRA)
  - OTC contract; users "lock in" implied forward rate

- Interest Rate Futures (IRF) and T-Bill Futures
  - exchange traded futures contracts
  - underlying: 90-day interest rate *(contrast with FRA)*

- Interest-rate Swaps
  - OTC contract; converts exposure: fixed <-> floating
  - Bundle of “time against time+6months” FRA’s

- Government bonds futures
  - Exchange-traded futures on a long-term government bond

T-Bond & T-Note Futures: Outline

- Bond quotes
  - money-market instruments
  - T-notes & T-bonds
  - corporate & municipal bonds

- T-Bond & T-Note futures
  - Pricing
  - Conversion factor
  - Options, including *wild card*
Bond Prices and Yield Quotes

- Money-market instruments
  - zero-coupon bonds
  - quotes vs. actual yields

- Long-term bonds
  - quotes
    » US government T-notes & T-bonds
    » corporate & municipal bonds
  - accrued interest

Long Term Bond Prices & Yield Quotes

- US government
  - T-Notes (< 10 years) vs. T-Bonds (10 to 30 years)
  - denominations (> $1,000), coupons (semi-annual)
  - bonds may be callable (typically last 5 years)
  - prices
    - quoted bond prices
      » (percentage + 32nds of 1%) of face value
    - accrued interest
      » n/N = actual # of days / actual # of days in ref. period
      » example: March 1 to July 7 → n = 124 days
Long Term Bond Prices & Yield Quotes 2

- Corporate & Municipal Bonds (NOT Exam Material)
  - denominations (> $1,000), coupons (semi-annual)
  - bonds may be call able (or, more rarely, put able)
  - prices
    - quoted bond prices
      - munis: (% + 8ths %) of face value
      - corporates (decimal): (% + 100ths %) of face value
    - accrued interest
      - 30/360 (vs. T-bonds: convention = actual/actual)
      - example: March 1 to July 7 = 4*30+2=122 days

T-Bond & T-Note Futures

- Contracts available (CBOT; Hull, Table 6.1)
  - T-bond futures
  - 2-year, 5-year, 10-year T-note futures
  - M-J-S-D cycle

- Long party
  - pays: quoted futures price * conversion factor + accrued interest
    (for each $100 of quoted face value)

- Short party
  - may deliver any bond – with some restrictions
T-Bond & T-Note Futures 2

- Options for short party
  - 1. bond to deliver
    - range of bonds can be delivered
    - dealt with by:
      » limit in bonds that can be delivered
      » conversion factor (varies with bond delivered)
  - 2. timing
    » timing sequence and futures contract trading
  - 3. wild card
    » closing times: bond market’s vs. futures market’s

T-Bond & T-Note Futures 3

- 1. Delivery option

<table>
<thead>
<tr>
<th>Futures contract</th>
<th>Time to maturity (from 1st day of delivery month)</th>
<th>Face value</th>
<th>Price quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-bond</td>
<td>m &gt; 15 years not callable for 15 yrs</td>
<td>$100,000</td>
<td>$ and 32nds of $ and 1/2 32nds of $</td>
</tr>
<tr>
<td>10-year T-note</td>
<td>10 yrs &gt;m &gt; 6.5 yrs not callable for 6.5 yrs</td>
<td>$100,000</td>
<td>$ and 32nds of $ and 1/2 32nds of $</td>
</tr>
<tr>
<td>5-year T-note</td>
<td>5.25 yrs &gt;m &gt; 4.16 yrs</td>
<td>$100,000</td>
<td>$ and 32nds of $ and 1/4 32nds of $</td>
</tr>
<tr>
<td>2-year T-note</td>
<td>5.25 yrs &gt;m &gt; 1.75 yrs</td>
<td>$200,000</td>
<td>$ and 32nds of $ and 1/4 32nds of $</td>
</tr>
</tbody>
</table>
T-Bond & T-Note Futures 4

• Conversion factor
  • why?
    » short party has large range of bond choices
    » so the playing field must be “leveled”
  • what?
    » commit short party to deliver “nominal” 6% T-bond
      (used to be 8% before March 2000; still 6% despite...)
  • how?
    » adjust bond price (to be paid by long party)
    » as if its annual YTM were 6% (3% semi-annual)
    » on 1st day of delivery month
  • in practice
    » CME Group (prev. CBOT) builds comprehensive tables

T-Bond & T-Note Futures 5

• Computing conversion factors
  – A. Simplification #1
    • what?
      » bond maturity and times to coupon payment date
      » are rounded off to closest (i.e., earliest) 3 months
    • examples
      » bond has 20 years and 2 months to maturity
        — assume bond has 20 years to go
      » first coupon is to be paid in 4 months
        — assume coupons start in 3 months
T-Bond & T-Note Futures 6

• Computing conversion factors
  – B. Simplification #2
    • I. bond has exact # of half years after rounding off
      – > assume 1st coupon is paid in 6 months
      – > assume other coupons are paid every 6 months thereafter
        » example: bond w/ 20 years & 56 days left, 10% coupon
          \[
P = QP = \sum_{t=1}^{40} \frac{5}{(1 + 0.03)^t} + \frac{100}{(1 + 0.03)^{40}} = $146.23
\]
        conversion_factor = \frac{P}{par} = \frac{$146.23}{$100} = 1.4623

T-Bond & T-Note Futures 7

• Computing the conversion factors
  – B. Simplification #2 (continued)
    • II. bond doesn’t have exact # of half years after rounding off
      » means there must be an extra 3-month period
      – > assume 1st coupon is paid in 3 months
      – > assume other coupons are paid every 6 months thereafter
        » example: bond w/ 18 years & 96 days left, 8% coupon
          \[
          QP = \frac{1}{(1 + 0.03)^{1/2}} \left( \sum_{t=1}^{36} \frac{4}{(1 + 0.03)^t} + \frac{100}{(1 + 0.03)^{36}} \right) = $123.99
          \]
T-Bond & T-Note Futures 8

• Computing the conversion factor
  – B. Simplification #2 (continued)
    • II. (continued)
      – > still need to take accrued interest into account
        » accrued interests would be paid at bond purchase
        » so no discounting of those

\[
P = QP - \text{accrued interest} = 123.99 - \frac{4}{2} = 121.99
\]

\[
\text{conversion factor} = \frac{P}{\text{par}} = \frac{121.99}{100} = 1.2199
\]

T-Bond & T-Note Futures 9

• Cheapest-to-deliver bond
  • long party
    » must take delivery of bond chosen by short party
    » worth: bond price + accrued interest
    » pays: futures price times conversion factor + accrued interest
  • short party
    » short party can deliver any bond
    » hence, it will buy the cheapest one on the market
    » that meets the requirements of the exchange
  • thus, must be bond for which :
    » futures QP times conversion factor - bond QP is highest
T-Bond & T-Note Futures 10

• Cheapest-to-deliver bond: example
  • futures price: current quote = 93:08
  • there are 3 deliverable bonds, with QP and CF:
    » #1 QP=99:16 CF=1.0382
    » #2 QP=143:16 CF=1.5188
    » #3 QP=119:24 CF=1.2615
  • cheapest to deliver? compute the cost of delivering
    » > $ loss for short = cost of buying bond spot - proceeds from long
      » #1: 99.50 - (93.25 x 1.0382) = $2.69
      » #2: 143.50 - (93.25 x 1.5188) = $1.87 (smallest loss)
      » #3: 119.75 - (93.25 x 1.2615) = $2.12

T-Bond & T-Note Futures 12

• 2. Timing option
  • 3-day delivery sequence
    » short can initiate any bus. day in delivery month minus 2 days
    » day1 (position day)
      » short informs clearing house of intent to deliver
    » day 2 (notice of intention day)
      » clearing corp. matches oldest long to delivering short
      » short invoices long
    » day 3 (delivery day)
      » short delivers to long
      » long pays
      » title passes (long has all ownership rights & liabilities)
T-Bond & T-Note Futures 13

• 2. Timing Option *(continued)*
  • last day of trading
    » deliverable contract stops trading
    » 7th business day *before* last business day
    » of delivery month
  • settlement
    » in that period, all positions *must* be settled by delivery
    » *but* short position still chooses when to deliver
  • value
    » short party may wait for cash prices to drop
    » so the option is valuable & reflected in futures price

T-Bond & T-Note Futures 11

• 3. Wild Card option
  • differences in closing time
    » futures stop trading on CBOT at 2PM, CST
    » intent to deliver by 8PM, CST
    » T-bonds stop trading *after* 2PM CST (4PM EST)
  • option for short party
    » can exploit decreases in cash prices & cheapest bond
    » by deciding to deliver after trading on futures ends
  • consequences for option pricing
    » theory
    » practice: assume all is known and use F-S parity
T-Bond & T-Note Futures 14

• T-bond futures pricing (NOT Exam Material)
  • theory
    » options need to be priced
    » tools to do so: Options
  • if options were worthless
    » assume all is known
    » use forward-spot parity \( I = PV \text{ of future cash-flows} \)
    » \( F_0 = (B_0 - I) e^{rT} \)
    » or \( F_{i,T} = (B_0 - I) e^{r(T-t)} \)

T-Bond & T-Note Futures 15

• Quotes & Marking to Market
  • example: go long 1(one) T-bond futures at open

| time          | futures price | margin requirement | cash-flow
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>01-11-02</td>
<td>$103,750</td>
<td>$2,700(a)</td>
<td></td>
</tr>
<tr>
<td>(morning)</td>
<td></td>
<td></td>
<td>Periodic</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- $2,700</td>
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<tr>
<td>01-11-02</td>
<td>$102,968.75</td>
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<td>Cumulative</td>
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<tr>
<td>(close)</td>
<td></td>
<td></td>
<td>- $3,481.25</td>
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<tr>
<td>01-15-02</td>
<td>$104,750</td>
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</tr>
<tr>
<td>(close)</td>
<td></td>
<td></td>
<td>+ $1,781.25</td>
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<tr>
<td>01-18-02</td>
<td>$102,750</td>
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<tr>
<td>(close)</td>
<td></td>
<td></td>
<td>- $2,000</td>
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<tr>
<td>01-22-02</td>
<td>$103,750</td>
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<tr>
<td>Then offset at</td>
<td>$103,750</td>
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<td>- $2,700</td>
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<tr>
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<td></td>
<td>$0</td>
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(a) Initial margin (Maintenance = $2,000)